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# A Summary of Proper Cold Weather Pavement Repair Methods

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| Abstract | Currently-available portable construction equipment can provide hot asphalt concrete on a year-round basis in cold regions. This permits rapid and permanent repairs to pavements if potholes occur or utility cuts are made when the local hot asphalt concrete plants are closed for the winter. |
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# A SUMMARY OF PROPER COLD WEATHER PAVEMENT REPAIR METHODS

by

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## INTRODUCTION

In 1981, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) published the Pothole Primer: A Public Administrator's Guide to Understanding and Managing the Pothole Problem (Eaton et al. 1981). Its purpose was to provide facts about the causes and costs of potholes in a short and easy-to-understand format. The Engineer's Pothole Repair Guide (Eaton et al. 1984) is similar in concept, but is intended for highway engineers, superintendents, and maintenance managers.

As was mentioned in the Pothole Primer, many highway engineers agree that expedient techniques for pothole patching are little more than exercises in futility. Nevertheless, proponents of such procedures claim that more permanent repairs are not cost-effective, because maintenance personnel must spend too much time preparing the hole, compacting the mix, etc. In terms of dollars spent, this logic simply does not hold up. If a pothole is not permanently patched the first time, subsequent trips must be made to refill the hole. Each time the same pothole is patched, its expense to the agency increases.

A study by the Pennsylvania Department of Transportation in 1976 showed that repeated pothole patching costs five times as much annually as a one-time permanent patch (O'Brien, 1976). In addition, a value engineering analysis from the Aberdeen Proving Ground in Maryland showed that permanent repair would save an estimated 70% of their current budget for temporary road re-

pair.* Clearly, savings can be realized by correctly repairing potholes or other pavement defects the first time, and this effort must be made by highway administrators and engineers.

## DISCUSSION

### Potholes

Most potholes that form in the winter or spring are temporarily patched, and then left until warmer months for permanent repair. Unfortunately, this system does not work well unless the repair is made correctly. Often these patches last only a few days, or in some areas, only a few hours.

Permanent repairs can be made in any season as long as the proper equipment and correct procedures are used. An initial investment in new equipment may be necessary, but the time and money spent on patching potholes correctly the first time will lead to a break-even point and eventually to substantial savings in maintenance costs. The equipment will literally pay for itself by reducing manpower and material requirements. In addition, liability for the agency is reduced if users have a safe road on which to travel. In short, the procedures and recommendations outlined in this paper will benefit all who are concerned with providing better roads.

Most potholes will result from one or more of the four main causes:

1. Roads that have insufficient thickness to support traffic during winter/spring thaw cycles without localized failures.
2. Poor drainage, which will usually cause failure in combination with thin pavements, but can also affect thick pavements and new overlays.

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* Aberdeen Proving Ground, Maryland (1982) Equipment Justification Value Engineering Document (worksheet).

3. Failures at utility trenches and castings.

4. Miscellaneous paving defects and cracks which are left open and unsealed from water intrusion.

The insufficient thickness of the roadway may be the result of a pavement that is too thin or that has an inadequate base, subbase and subgrade.

Drainage problems can result from inadequate slopes due to poor design or to low spots from settlement of base, subbase and subgrade materials. Potholes frequently occur at curb lines, and at intersections where roads with different cross-slopes intersect. Often, drainage problems can be caused by inadequate maintenance of drains and ditches at the shoulders of the roadways. A periodic program of clearing ditches of vegetation and debris from storm drains and culverts can greatly increase the longevity of the roadway surface.

Well-drained base and subbase materials will, of course, reduce the incidence of frost heave -- a major cause of potholes. In well-drained soils, water will not be drawn upward from the water table to cause ice formation at the freezing front and subsequent frost heave.

Failures at utility trenches and castings are often the results of improper installation. (See the Pothole Primer for a discussion of this problem.)

Paving defects and cracks can be caused by such things as plastic deformation, subgrade or base consolidation, entrapped water or just normal wear. An important maintenance operation is the sealing of surface cracks to prevent water intrusion.

A pothole develops when two factors are present at the same time: water and traffic. Since water and traffic must be present

together, it can easily be seen that the most common location for pothole development is in the wheel paths of traffic.

Utility Cuts or Other Localized Pavement Failures

A water or sewer line may break or differential frost heave may occur, necessitating repairs during cold weather when the hot mix plants are closed. If no hot asphalt concrete is available to make a permanent repair, temporary repairs are generally made with lower quality cold mix, gravel, or other material which may last only hours under heavy traffic.

As previously discussed, it is most economical to make a permanent, one-shot repair.

Material for Patching

Many materials are available for patching flexible pavements (Eaton et al. 1984, and Asphalt Institute 1983). Based upon our research and current practice, the best material for patching potholes, utility cuts, or other pavement defects is hot asphalt concrete from an asphalt plant.

In cold areas, however, the hot mix plants are generally closed from late November to April each year.

One way to provide high quality materials without paying premium prices is to order hot mix asphalt concrete that meets local or state highway specifications in the fall before the hot mix asphalt plants close. This hot mix should be tailgate spread in a layer 6 to 8 in. thick on a relatively clean paved area. After the hot mix has cooled, it can be broken up with a pavement breaker, or front-end loader, and stockpiled under a cover.

With currently available, relatively inexpensive, portable recycling equipment, hot mix asphalt concrete can be supplied year-round. In the winter, the equipment can be used to heat this stockpiled asphalt concrete above 250 F for pothole patching and in the summer the same equipment can be used to keep the asphalt concrete, picked up at the hot mix plant in the morning, hot all day and even overnight. It will eliminate most of the waste caused by a load of asphalt that has cooled below State or local specifications by providing a means of reheating and allowing the asphalt to be used in an acceptable manner.

Patching Equipment

Four types of equipment are needed for effective pothole/utility cut patching:

1. Cleaning, tacking and sealing equipment.
2. Hole preparation equipment.
3. Compaction equipment.
4. Mix equipment.

Cleaning, tacking and sealing equipment. Cleaning, tacking, and sealing equipment should include brooms, brushes, spray cans (for tack and seal), rags, and torches (for drying). Ideally, an air compressor with a sprayer will be used for blowing debris from the hole and also for drying. Then spray cans will provide low pressure application of the tack and seal coats. Any type of broom or brush can be used to remove water and loose debris from the hole before squaring and undercutting it. Rags will be needed for cleanup and, if required, a torch can be used to dry the hole. A torch is also useful in heating and cleaning rakes, shovels and other equipment used in the patching operation.

Hole preparation equipment. The best tool for squaring a hole and making vertical sides is a pavement breaker (jackhammer). A chisel point with one flat side is recommended, so that the sides of the hole will be vertical.

A power saw should not be used because it leaves smooth sides that do not provide good bonding for the tack coats or patch. Such saws should be used only if pavement breakers are unavailable and there is no other way to make the vertical sides.

Compaction equipment. The most important step prior to and during and after patching is compaction. The repair crew must try to obtain optimum density in order to make the patch last longer and keep the water out. (It is unlikely that a pothole patch will ever be over-compacted, given the conditions that usually exist during the patching operation.)

Vibrating plate or vibrating roller compactors are the most suitable because they "work" the mix while it's hot and help densify it by vibration.

The next most effective compactors are the heavy "static" or non-vibrating steel wheel rollers for larger potholes.

Based upon a controlled pothole compaction study in 1983 at CRREL (Snelling and Eaton 1984), it was found that a 166-lb, 21- x 24-in. vibratory plate compactor obtained at least 98% lab density on an 18- x 24- x 6-in. single lift patch with the asphalt above 250°F.

If other types of compactors are used (such as hand tampers), place the hot material in 1- to 2-in. lifts and take extra care to properly compact the patch. As stated before, this is the most critical part in the patching procedure and determines the life of the patch.

The hole should be overfilled by 1/4 to 3/4 in., depending on the depth of the hole (1/4 in. for holes up to 2 in. deep, 1/2 in. for holes 2-4 in. deep, and 3/4 in. for holes more than 4 in. deep). This is for guidance only and will vary depending on the

mix you use. This overfilling is required to allow for compaction. When compaction is complete, the patch surface should be just slightly higher than the surrounding pavement so that a "birdbath" or low spot does not exist where water will collect and cause future problems.

Mix equipment. There are many types of equipment that can be used to mix, heat, or recycle patching material. These include recyclers, stockpile heaters, and hot boxes.

Most portable recycling machines are designed to be towed behind a pickup or dump truck which can be brought near the holes being patched. Some have provisions for allowing broken pavement pieces to be thrown from the pothole directly into the machine and recycling at the repair site.

Recycling machines (mix equipment) usually will require a crew of at least 4 or 5 to ensure good production. The actual machine and procedure will dictate how many workers will be needed for the job.

Some of these portable stockpile heaters can be set up at a central maintenance yard and used like a miniature asphalt plant. Stockpiled cold mix, chunks of broken asphalt pavement, or virgin aggregate to which liquid asphalt cement is added can be used. These "portable plant" machines prepare mix that is then loaded into trucks with hot boxes and then delivered to the work site.

The hot boxes can be little more than insulated boxes, or they may have their own heat source. Commercially available trailer-type hot boxes, 2- or 4-ton insulated boxes on wheels, are heated underneath and along the sides by LP gas. They can also be mounted on trucks.

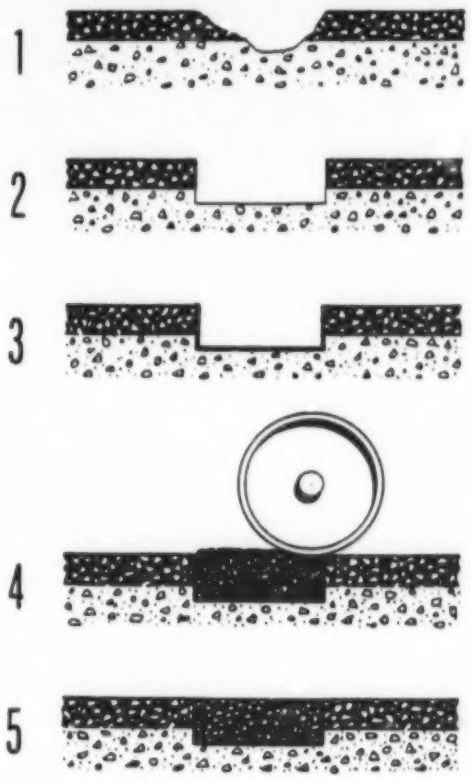


Figure 1. Pothole permanent repair. 1) Untreated pothole, 2) Surface and base removed to firm support, 3) Tack coat applied, 4) Full-depth asphalt mixture placed and being compacted, 5) Finished patch compacted to level of surrounding pavement.

## Repair Procedures

There are seven basic steps to pavement pothole patching. Some steps can be adjusted to the conditions that exist, but for the most part, all steps must be closely followed to ensure a long-lasting patch (Fig. 1).

Of course, before the patching is begun, one should have determined that this is the correct procedure. For example, in badly deteriorated sections, a complete overlay may be required. Of utmost concern should be the safety of the repair crew.

1. Marking - The area around the pothole must be marked with chalk or paint in order that the workman doing the cutting can easily and quickly remove the failed material. Marking is done to include only portions of the pavement that will provide a good surface against which the patch is to bond; that is, these portions should have no cracks and appear solid compared to the area immediately adjacent to the pothole.

2. Cutting - The workman doing the cutting should avoid cutting more than is marked (excess cutting reduces cost effectiveness due to increased material use). The walls of the hole should be made vertical to provide a good surface for adhesion and "locking" the patch in during compaction. Cutting should continue to a depth where good pavement or base material exists.

If the pavement that is cut away is to be recycled, care should be taken to avoid including base and subbase material to prevent contamination of the mix. When the cutting is complete, the large chunks of pavement should be removed and stockpiled, if not used immediately, for future recycling.

3. Cleaning - This step includes removing any remaining debris from the hole. (Compressed air works well for this.) If the hole has been made to the base or subbase, these materials, if disturbed, must be compacted so that compaction by traffic will not occur after the patch is in place.

If the hole has water in it, the bonding of the patch will be poor. The hole must be dried as much as possible by using compressed air, a torch, rags, broom, etc.

It should be stressed that all debris must be removed from the sides of the hole. Loose material will cause a poor bond, and lead to early failure of the patch.

4. Tacking - A tack coat should be used to provide a bond between old and new surfaces. Too much tack coat will result in an excess amount of asphalt, which will lead to rutting, and eventual failure of the patch.

Hot mix, as well as recycled mix or cold mix, should always be tacked. The best method for tacking is to spray the tack in a thin coat. Brooming and pouring are generally not effective be-

cause excess tack material usually accumulates at the bottom of the hole around the edges.

Either cutbacks or emulsions are used for tacking and they are described in the "Materials" section of CRREL Technical Digest 84-1 (Eaton et al. 1984).

5. Placing - Holes deeper than 6 in. should be filled (and compacted) in more than one lift. Placing should be done with a shovel in one lift working from one side of the patch to the other. To prevent segregation, the material should be laid, rather than thrown or raked, into the hole. The patch should be made so that after final compaction, it is slightly (about 1/8 in.) above the surrounding pavement to allow possible future compaction by traffic and eliminate "birdbaths." No patching material should be left on the surrounding surface.

6. Compaction - It is crucial that the patch be compacted properly. Poor compaction will cause shrinkage of the patch, allowing intrusion of water around the edges and ultimate failure.

The compaction method should match the size of repair. A 1-ft$^2$ patch does not require compaction with a 10-ton tandem steel-wheeled roller. Most road repairs can be made with small- to medium-sized vibrating plate or roller compactors. Care should be taken by the operator to ensure that the compaction force is directed on the patch and not the surrounding pavement.

7. Edge Sealing - Edge sealing is done to keep water out of the joint between the pavement and patch. Any material can be used, so long as it does not cause excess asphalt to bleed around the patch. A layer of fine sand can be used to blot the seal.

## SUMMARY

Initial preparation for cold weather patching requires purchase of 25-50 tons of hot asphalt concrete which meets local state or province specifications for pavement construction.

The hot mix should be tailgate spread in a 6- to 8-in. lift on a clean surface and allowed to cool. It should be broken up and stockpiled under cover until needed.

As hot asphalt concrete is needed in cold weather, the stockpiled material can be recycled using portable recyclers or hot boxes. This procedure will provide 250°-300°F asphalt concrete to make permanent repairs following the seven-step repair procedures described in this paper.

By following these methods, permanent one-shot repairs are possible when the asphalt plants are closed in cold weather, thereby eliminating costly repeat visits when inferior materials or methods are used.

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## REFERENCES

Asphalt In Pavement Maintenance (1983) Manual Series No. 16, The Asphalt Institute, Asphalt Institute Building, College Park, Maryland.

Eaton, R.A., Joubert, R.H. and Wright, E.A. "Pothole Primer: A Public Administrator's Guide to Understanding and Managing the Pothole Problem," U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) Special Report 81-21 revised April 1985.

Eaton, R.A., Wright, E.A. and Mongeon, W.E., "The Engineer's Pothole Repair Guide," CRREL Technical Digest No. 84-1, March 1984.

O'Brien, L., "Value Engineering As Applied to Pothole Patching," Paper presented at AASHTO Meeting, Birmingham, AL, Nov. 1976.

Snelling, M.A. and R.A. Eaton, "Comparison of Three Compactors Used in Pothole Repair," CRREL Special Report 84-31, Nov. 1984.